PELLETIZATION OF IRON ORE CONCENTRATE FROM FLUORSPAR TAILINGS

Dr. Willie Nheta

Miss Jeanette Mashigo

University of Johannesburg, **South Africa**

ABSTRACT

Many low grade iron ore deposits which were previously ignored are being treated due to depletion of high grade iron ore deposits. Haematite flotation concentrate from a reverse flotation of fluorspar tailings was characterised and agglomerated using bentonite and coke. The effect of bentonite and coke concentrations on mechanical strength and metallurgical characteristics of the wet and baked pellets was investigated. It was found that the concentrate contained 60.5% Fe, 4.24% silica and other minor elements. Major mineral phases present were hematite, magnetite and silica. A maximum wet drop number of 3 and wet strength of 2.85N was obtained when using 1.25 and 0.75wt% bentonite respectively. The maximum dry and baked strength obtained was 28.1N and 2690N respectively whilst using 1.25wt% bentonite and no coke. Porosity of the baked pellets was not affected very much with change in coke concentration which is not the usual case with iron ores. At high coke concentration (3wt %), the pellets contained spinels.

Keywords: Pelletization, agglomeration, flotation, mechanical strength, binder

INTRODUCTION

Recently processing of high grade iron ore in South Africa and the world over has decreased. It is due to depletion of high grade ores. This has led to processing of low grade iron ores which were previously ignored. Iron ore is low grade either due to low iron content or due to high silica content. Many low iron grade ores are finely disseminated. These ores require a fine grind to liberate the iron oxide. The fine milled product can be concentrated using flotation as compared to the usual gravity and magnetic concentration processes used in treatment of iron ores [1-3]. However, the product from flotation concentration process is too fine to be transported and processed in iron making plants and there is need to agglomerate it before transportation and blast furnace charging [4, 5]. Nheta et al [2] listed all the agglomeration process that can be used to agglomerate the flotation concentrations. It was concluded that pelletization is the best way of agglomeration of iron flotation concentrates.

Quality of pellets is assessed based on the mechanical strength and metallurgical characteristics. According to Mbele [4], good pellets must have a high wet drop number, high mechanical strength for both wet and dry pellets, and must be porous. It must also contain high iron content and low silica content. All these characteristics depend on the flotation process, type and amount of binder and coke used.

The usual binder used in iron ore pelletization is bentonite. Bentonites are classified and named according to their dominant element. Calcic bentonite is (calcium rich), sodic

bentonite is (sodium rich). Sodic bentonite is mainly used as a binder, because of its ability to absorb water and swell. Calcic bentonite is used mainly in the cleaning reagents industry. Calcic bentonite can be activated with soda ash, to make it acquire the properties of sodic bentonite, and thus be used as a binder in iron ore agglomeration. To determine whether bentonite is calcic or sodic, swelling index tests are done. Sodic bentonite swells up to ten times the initial mass of bentonite used for the swelling test [6].

This paper investigate the possibility of using low grade iron ore concentrate from fluorspar tailings as charge into the blast furnace.

MATERIALS AND METHODS

Materials

The iron ore concentrate used in this research work was obtained from reverse flotation of fluorspar tailings obtained from Vergenoeg Mining Company in Gauteng province, South Africa. The flotation process was carried out according to the procedure described by Nheta et al [2]. All the reagents used in flotation were sourced as AR grade from Merck and Associated Chemical Enterprises. Bentonite with purity of 99% was obtained from Merck.

Methods

Characterization

The concentrates obtained from flotation of fluorspar tailings were analyzed using X-ray diffraction (XRD), model Ultimate IV X-ray diffractometer. For chemical composition, it was analyzed using the X-ray fluorescence (XRF), model (Rigaku Primus II). The particle size distribution of the concentrate was obtained using the Malvern particle size analyzer; model (Microtract S5300).

Palletization experiments.

The flotation concentrate, binder (bentonite) and coke were intensively mixed in a mixer for 30seconds. For every 5kg of iron ore pelletized, bentonite dosages were varied according to dosages shown in Table 1. The mixture was charged into a pelletizing disc rotating at a speed of 60rev/min and at an angle of 40-45^{O} to form green pellet seeds. The pellets were moistened with water sprays hanging on top of the pelletizer, once the pellets seeds had formed. Green pellets were moved periodically and screened to control desired size of between (+10mm and -16mm). The screened pellets were allowed to air-dry for 48 hours to remove moisture. The air dried pellets were then baked at 1300^{O}C under an oxidizing atmosphere for about 15minutes to improve their strength.

Table 1: Pelletizing mixtures

Batch no	1	2	3	4	5	6	7	8

wt% Bentonite dosage	0.75	1.00	1.25	0.75	0.75	0.75	1.00	1.25
wt% Coke dosage	0	0	0	1	2	3	2	2

Mechanical strength tests

a) Wet pellets drop test

Tests for strength on freshly agglomerated pellets were done using the Drop number method. Twenty pellets obtained from the pelletizing disc were dropped from a height of 45cm, the number of drops from this height before the pellets broke or get deformed were counted and results recorded.

b) Dry pellets strength test

A strength tests on dry pellets was done using a force gauge. Twenty dry pellets were compressed with a force gauge which records the highest peak of force at which the pellet breaks.

c) Compressive strength test.

A test for compressive strength of the baked pellets was performed using the Instron compressive strength tester where pellets were subjected to mechanical stress according to procedure described by Mbele [4].

RESULTS AND DISCUSSION

Characterization of the concentrate

The concentrate contained 60.45% Fe and 1.98% Si and other minor gangue such as calcium and fluorite. Major mineral phases present were hematite, magnetite and silica and minor amount of calcium oxide and fluorite. The particle size distribution of the flotation concentrate was assessed and the results are shown in Figure 1.

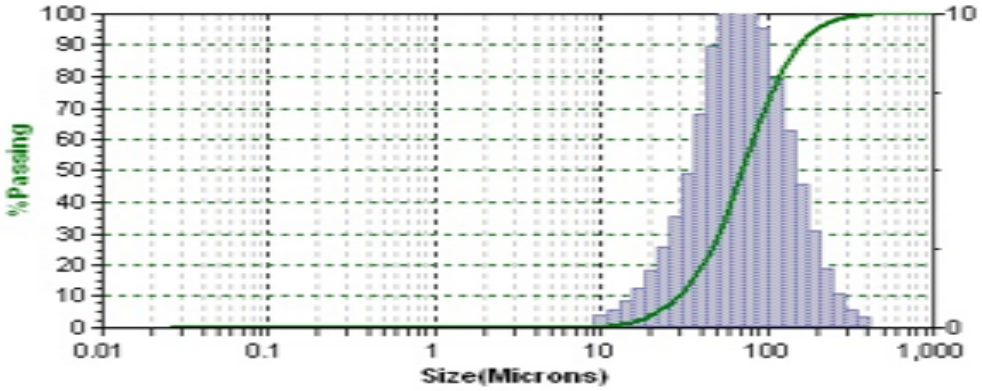


Figure 1: Particle size distribution for iron ore concentrate

Figure 1 shows a P80 of 100µm. The required particle size for palletization is 80% passing 75µm [4]. The sample was milled to meet the required particle size and used in the pelletization experiments.

Mechanical strength tests

Wet drop number

After pelletizing using three different binder dosages, twenty freshly agglomerated pellets were subjected to a wet drop test and the results are shown in Figure 2. At a binder dosage of 0.75% and 1%, the wet drop number was found to be 2 and at a binder dosage of 1.25% the wet drop number increased to 3.The desirable wet drop number for pellets in an iron ore pelletizing plant is 5. This number is based on the number of times the wet pellets will fall from one conveyor to the next as the pellets travel from the agglomeration stage through to the baking stage. The addition of coke did not have any effect on the pellets wet drop number. A low wet drop number might be due to a low Blaine number.

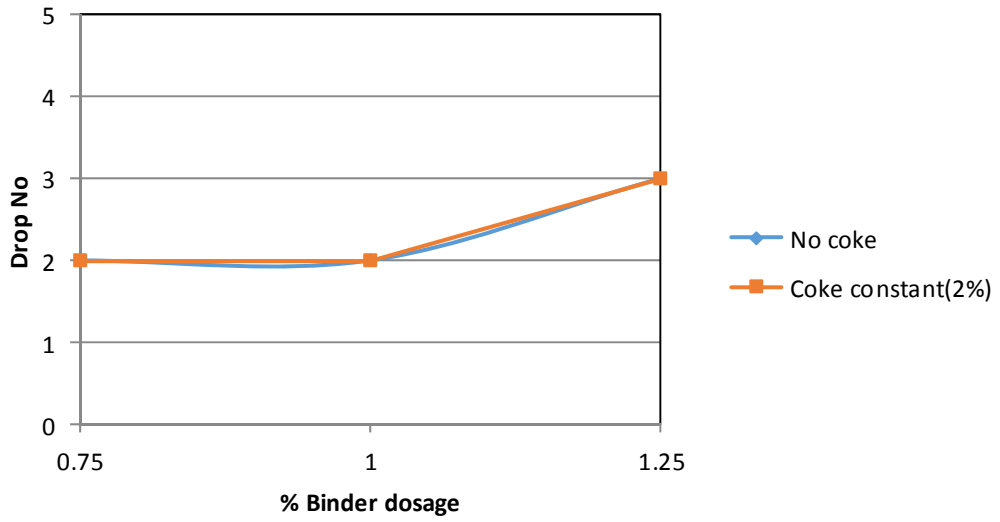
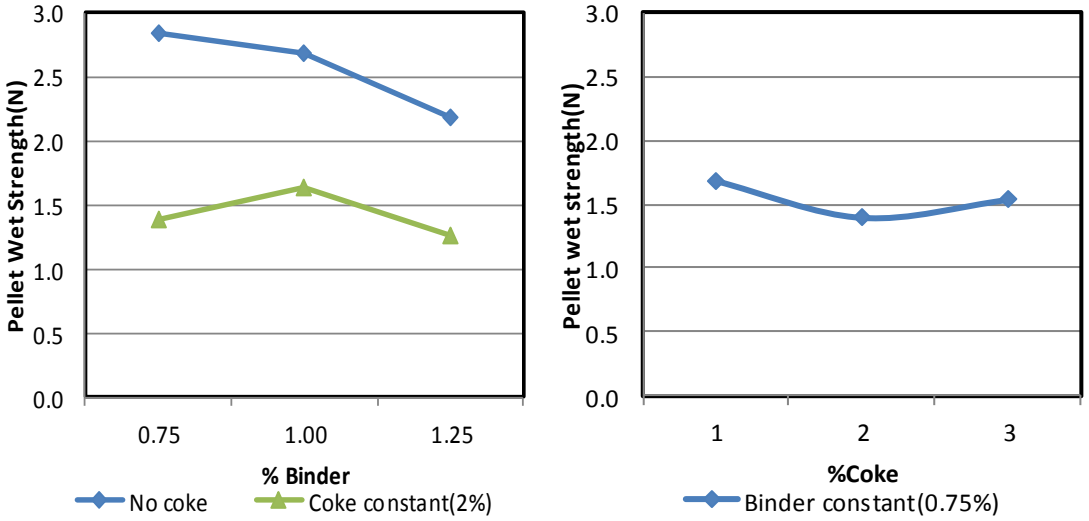


Figure 2: Wet drop number

Wet pellets strength

Figure 3 shows the results obtained after wet pellets were subjected to stress with the use of a force gauge. Figure 3a shows an inverse proportion relationship between the binder dosage and the pellets wet strength. Figure 3b shows the effect of coke on pellets wet strength at a constant binder content. Adding coke on the pellets did not improve the strength of wet pellets as expected but the pellets wet strength decreased with an increase in coke addition.

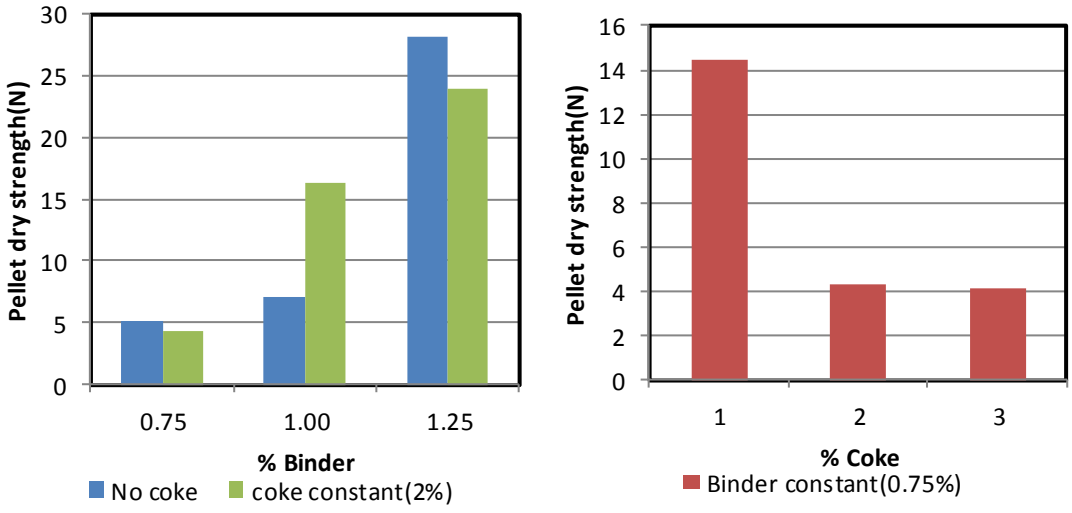


a *b*

Figure 3: Pellets wet strength

Dry pellets strength

The dry strength of baked pellets with and without coke was investigated and the results are shown in Figure 4. Figure 4*a* shows an increase in the pellets dry strength as the binder dosage increases with or without coke addition. Figure 4*b* shows that at constant binder dosage of 0.75wt%, the wet strength decrease drastically from 14 to 4N with coke addition of 1wt% and 2wt% respectively. The required dry strength for pellets is 22N [4, 5]. Only pellets with a binder dosage of 1.25% gave the desirable dry strength.

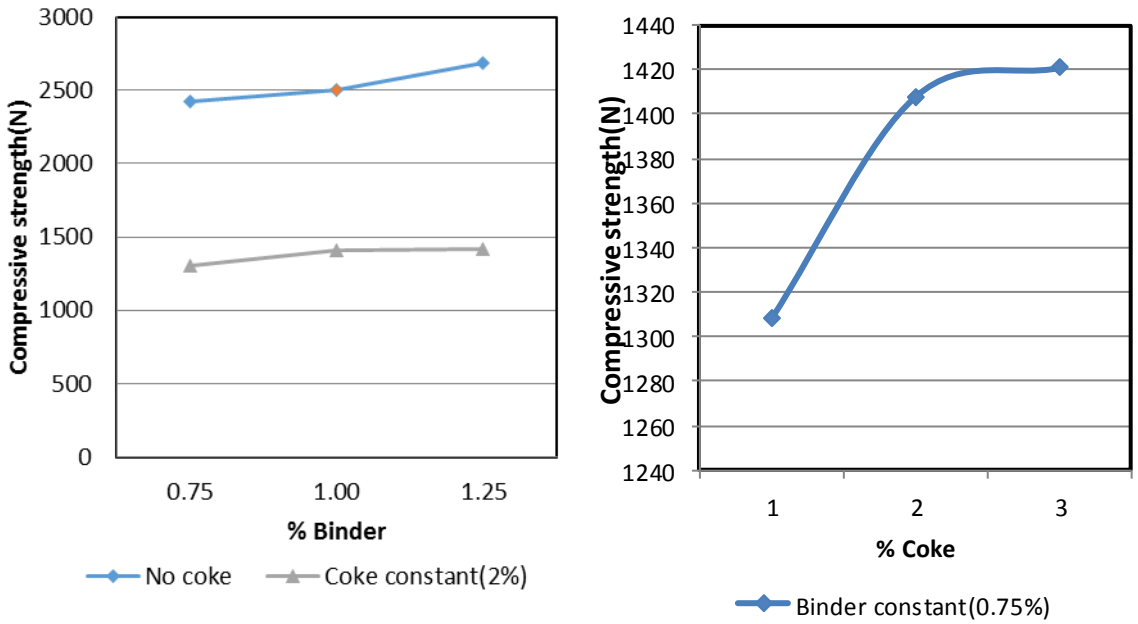


a *b*

Figure 4: Pellets dry strength

Baked pellets strength

The compressive strength of the baked pellets was measured and the results shown in Figure 5. From figure 5*a* it can be seen that pellets with no coke had a better compressive strength than those with coke. Compressive strength increased from 2400 to 2690N with increase in bentonite concentration form 0.75 to 1.25wt%. The required strength for pellets to be charged into a blast furnace is 2000N.



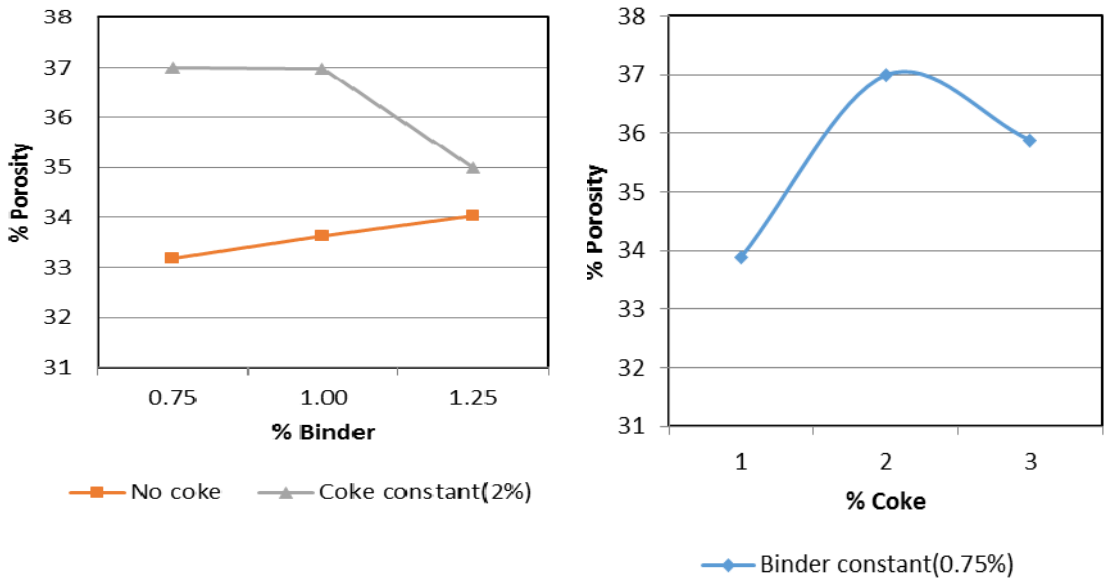
a *b*

Figure 5. Compressive strength of the baked pellets

Figure 5b shows the results when coke was varied at a constant binder concentration of 0.75wt%. The strength of the pellets increased with the increase in coke additions, but did not attain the required strength of 2000N. During pellet drying and baking, the pellets that have a higher concentration of the bentonite developing a solid bridge. This bridge has a disadvantage on dry pellets as it reduced the dry strength, but has an advantage on baked pellets due to heat hardening during pellet baking [5-8]

Porosity of the baked pellets

The porosity of the baked pellets was measured and the results shown in Figure 6. Figure 6a shows that pellets with a constant content of coke (2wt %) gave better results than pellets with no coke. Porosity decreased from 37 to 35% with increase in binder concentration from 0.75 to 1.25wt% respectively. Figure 6b shows that adding coke increases the porosity of pellets to a maximum of 37% at 2wt% coke. Further increase in coke concentration to 3wt% leads to a decrease in porosity to 35.88%. At higher coke concentration, the pellets melt and stick together during baking and reduce the number of pores in the pellets. Another possible reason for this decrease is that carbon increases the formation of low melting iron silicate phases by lowering their melting point, thus blinding the pores of the grain structure [4-6]. Well fired pellets have a porosity of 20-35% [6].



a *b*

Figure **6**: Porosity of the baked pellets

Characterization of Baked pellets

Chemical composition.

Characterization was done on baked pellets with a binder dosage of 0.75wt% and no coke added as this batch gave better results as compared to all the other batches. The chemical composition of baked pellets are shown in Table 3.

Table 2: Chemical composition for baked pellets, 0.75wt% Bentonite

Element	Fe_2O_3	SiO_2	CaO	F
wt%	84.61	6.14	3.73	1.05

The iron content on the pellets decreased to 59.18% (Fe_2O_3 – 84.61%) as compared to the concentrate which was 60.45%. The silica content has increased from 4.9% to 6.14%. The increase in silica and alumina is mainly because bentonite consists mainly of silica and alumina. The presence of high contents of CaO produces more calcium-alumino-silicate phases (slags). These phases have low melting points which causes sticking behavior of pellets as well as making baked pellets strong [7].

CONCLUSION

The iron ore concentrate obtained from fluorspar tailings coming from Vergenoeg mine was found to have an iron grade of 60.45%, which is an acceptable grade for iron ore

pellets to be considered as economical in iron production. The optimum pelletizing conditions were achieved with a bentonite binder having a concentration of 0.75% with no coke added though the pellets did not perform well on the drop number test, wet and dry strength. This mixture produced pellets with a compressive strength of 2420N, while the acceptable compressive strength for baked pellets is 2000N. The pellets produced with this mixture had a porosity of 33.18% whilst well fired pellets must have a porosity of 20-35%. Coke additions are not necessary as the pellets without coke have acceptable percentage porosity.

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